Accelerated Insertion of Materials - Composites

A New Way to Design Composite Structures

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for the
Innovative Design Workshop
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NAVAIR

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What is AIM-C?

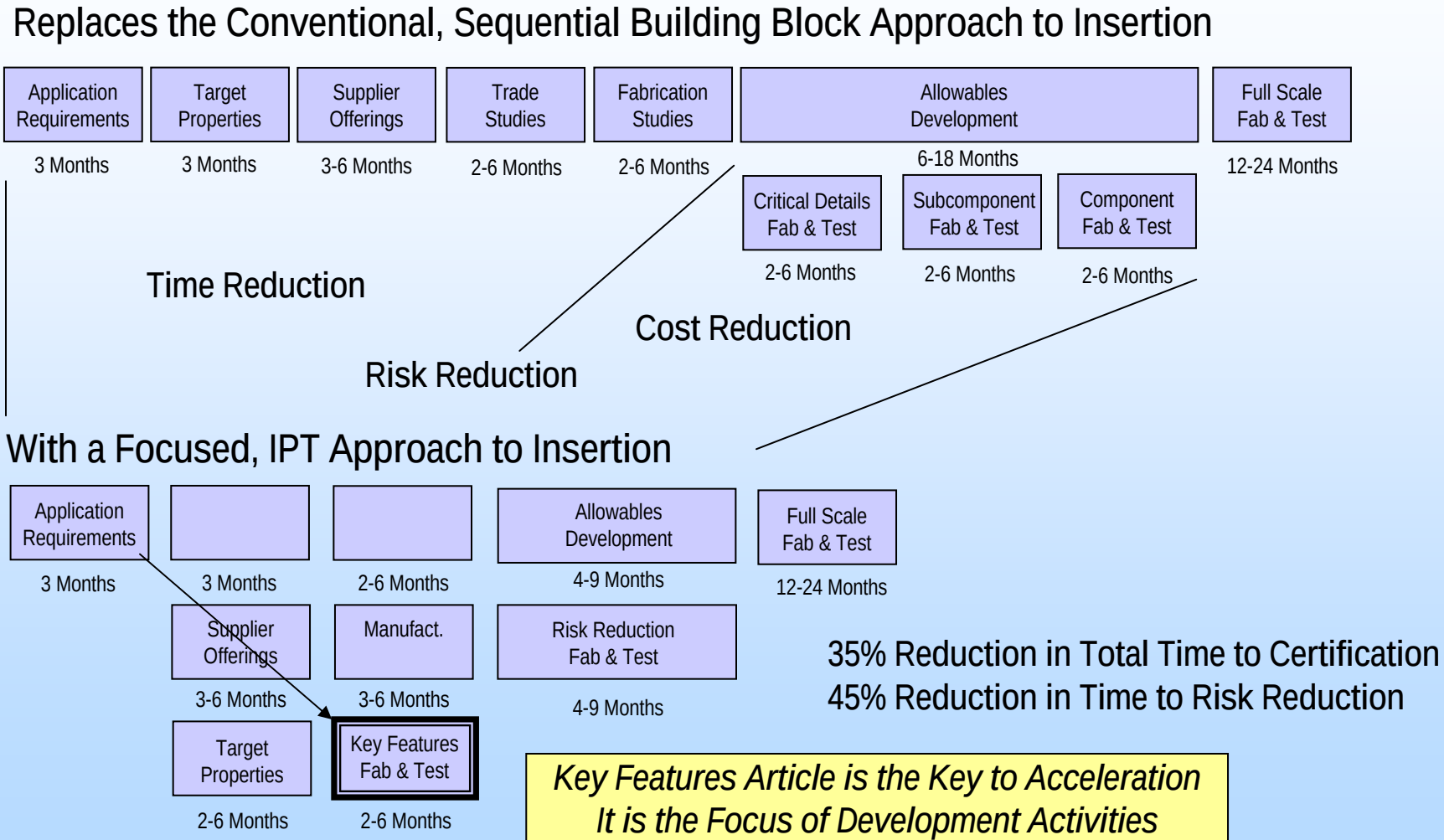
AIM-C is a methodology for accelerated insertion of materials into defense structures at reduced costs.

This methodology develops a design knowledge database that links what is known about a material system to what is needed in order to qualify its application to an application that meets certification requirements

It allows rapid identification of which applications are too risky and which are not.

It uses verified analysis methods, existing test data, and lessons learned from previous experience to minimize the amount of data required to insert new materials into a system with confidence

What Does AIM-C Do?

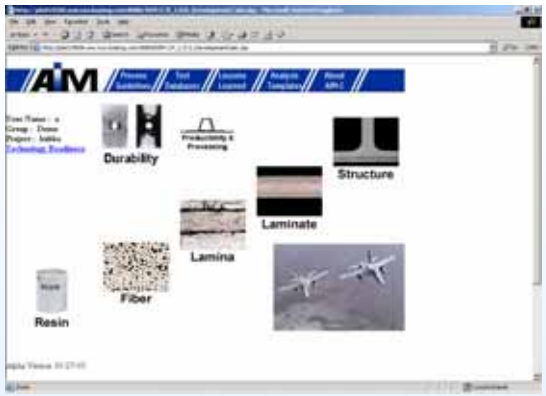


How Does AIM-C Accelerate Insertion?

- Focuses on Real Insertion Needs (Designer Knowledge Base)
- Identifies the Necessary IPT and provides IPT with Readiness Level Status
- Coordinates Use of
  - Existing **K**nowledge
  - Validated **A**nalysis tools
  - Focused **T**esting
- Provides Access to the Latest Physics Based Material & Structural Analysis Methods
- Uses Integrated Engineering Processes & Simulations
- Uses Uncertainty Analysis and Management
  - Focuses on Early Feature Based Readiness Demonstration
  - Tracks of Variability and Error Propagation During Scale Up

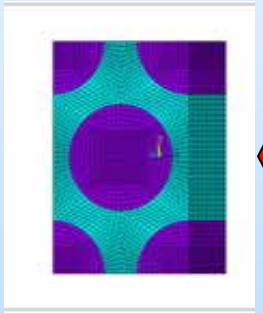
Provides Orchestrated Knowledge Management to efficiently tie these elements to the Design Knowledge Base

How Do I Use AIM-C?

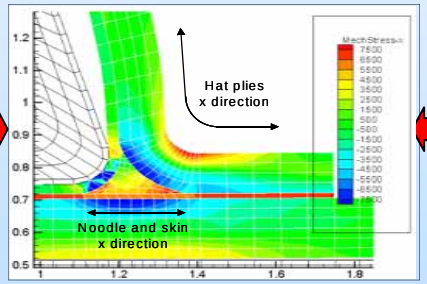


Web-Based System Delivery

Process Guidance and Risk Reduction Status



AIM-C Contains Analytical Models From Constituents



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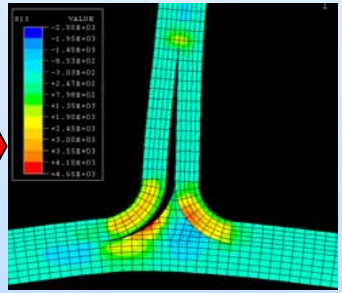
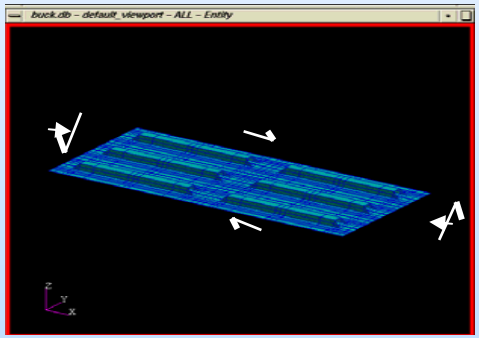


To Effects of Defects

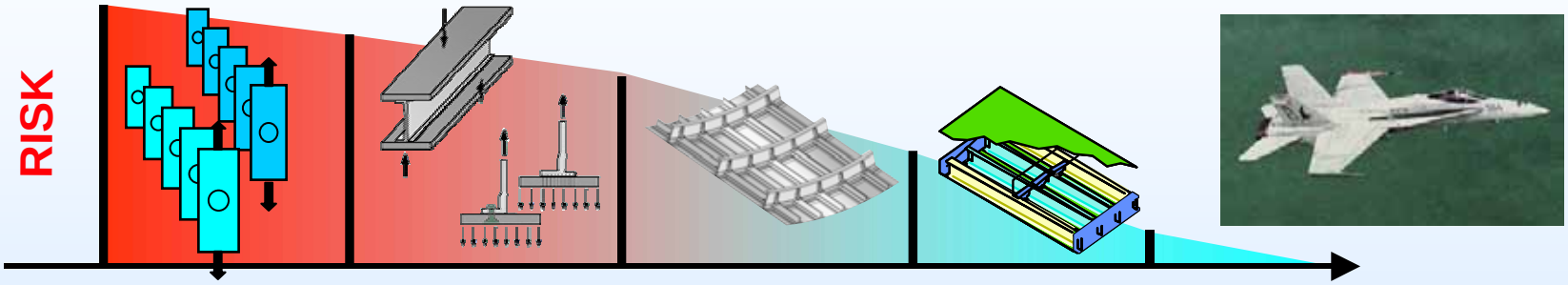


To Structural Reqs.

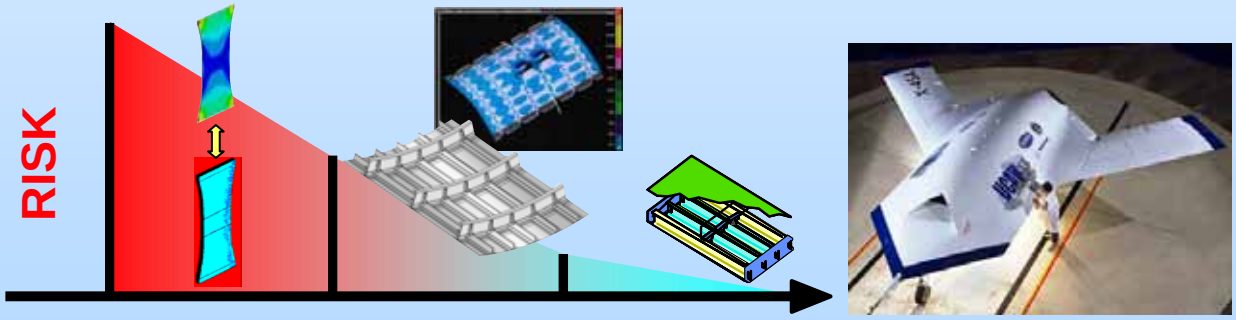
To Provide Analysis Supported by Test To Technology Readiness

What's the Benefit of AIM-C?

Traditional Test Supported by Analysis Approach



AIM Provides an Analysis Approach Supported by Experience, Test and Demonstration



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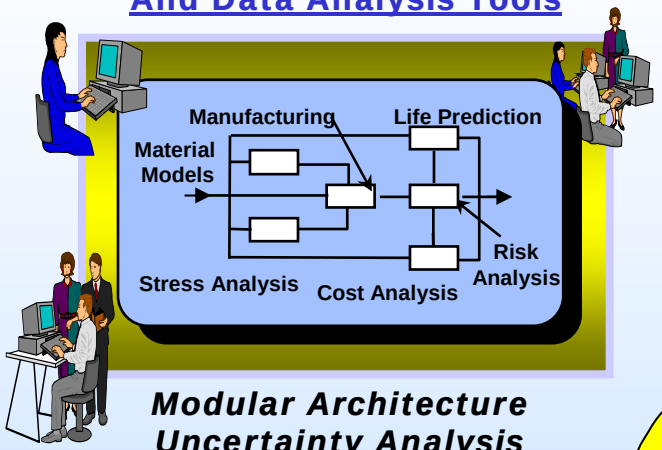
The Approach

Integrated Modeling/Simulation And Data Analysis Tools



Modular Architecture Uncertainty Analysis

Optimized Building Block Approach

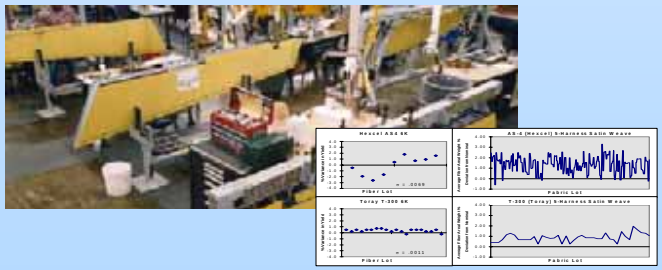
Application Requirements	Trade Studies	Design Features	Allowables Development	Full Scale Fab & Test
	Supplier Offerings	Manufact. Features	Risk Reduction Fab & Test	
	Target Properties	Key Features Fab & Test		

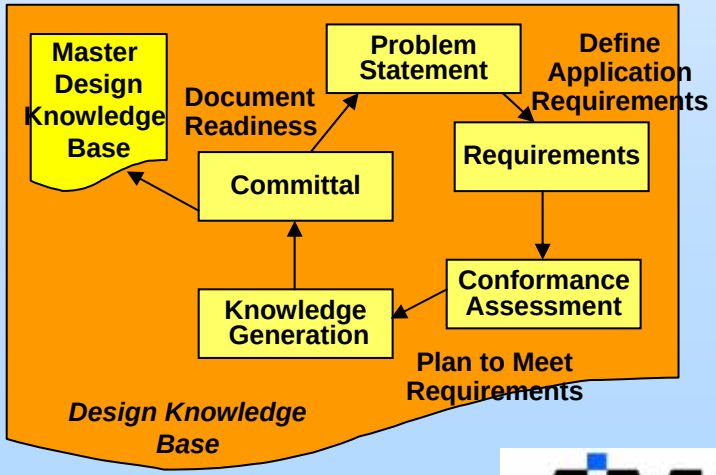
Technology Readiness Levels

METHODOLOGY

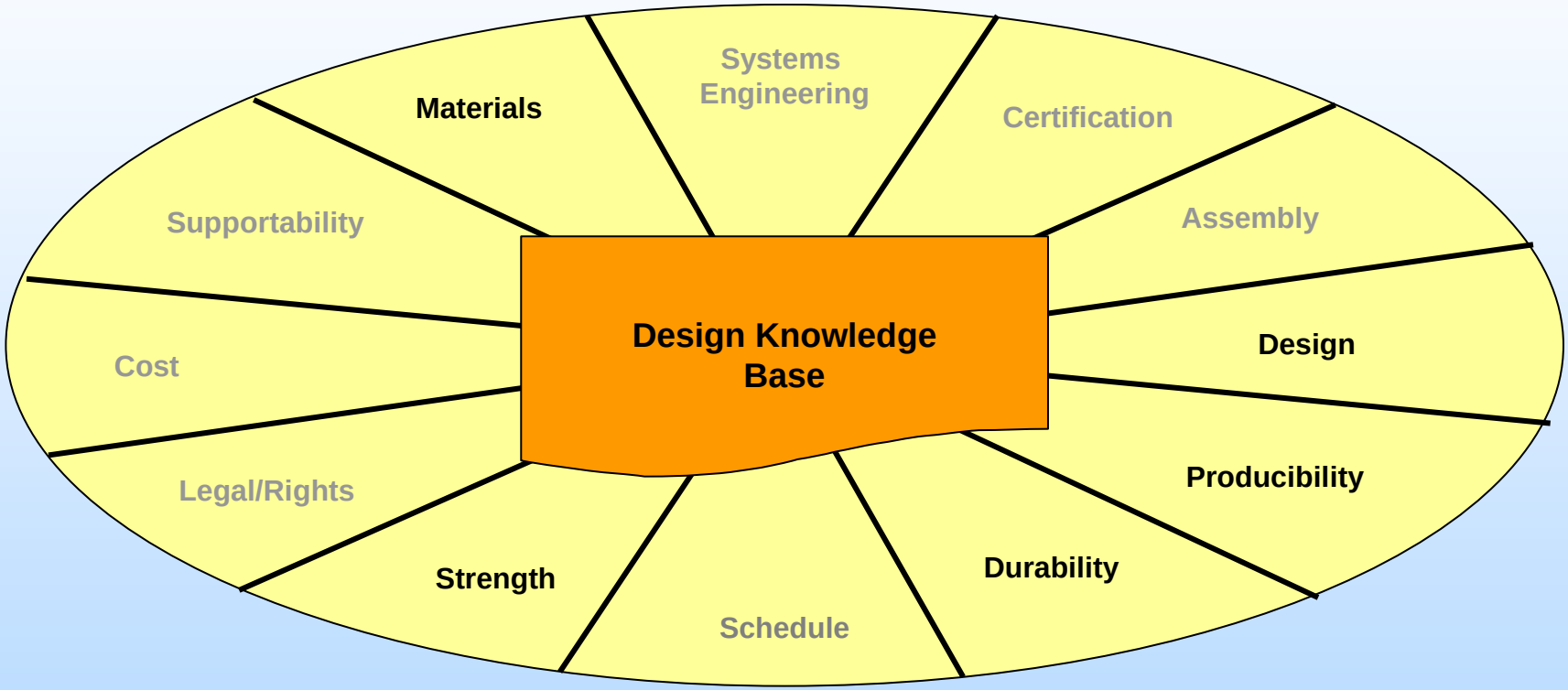
Producibility Issues

- Simulations
- Heuristics
- Lessons Learned





The AIM-C Process Uses the IPT to Commit Data to the DKB



All functions contribute – All receive data from the DKB

AIM Allows the IPT to Track and Plan Progress Toward Successful Insertion

TRL	0	1	2	3	4	5	6	7	8	9	10
IPT Reviews	Technology Insertion Readiness	System Requirements Review	Material and Process Readiness	Key Features Design and Fabrication	Key Features Test / Conformance	Preliminary Design	Critical Design / Ground Test Readiness	Flight Test Readiness	Production Readiness	Operatioinal Readiness	Technology Insertion Readiness
Application / Design											
Certification											
Assembly											
Structures / Durability											
Fabrication / Quality											
Materials & Processes											
Supportability											
Survivability											
Cost / Schedule											
Intellectual Property											

Technology Readiness Levels Differ in Focus

Technology Developers See TRLs Focused on That Development

Technology Readiness Levels													
Technology Development	1	2	3	4	5	6	7	8	9				
Application Development				1	2	3	4	5	6	7	8	9	10

Application Developers See TRLs Focused on Insertion Into Their Products

Technology Readiness Levels													
Technology Development	0.25	0.50	0.75	1	2	3	4	5	6				
				One Team									
Application Development			0	1	2	3	4	5	6	7	8	9	10

AIM Developed TRLs Focused on Insertion but Linked Technology and Application Developers Into One Team

At Each Step Each Discipline Follows A Defined Process for Knowledge Committal

TRL	0	1	2	3	4	5	6	7	8	9	10
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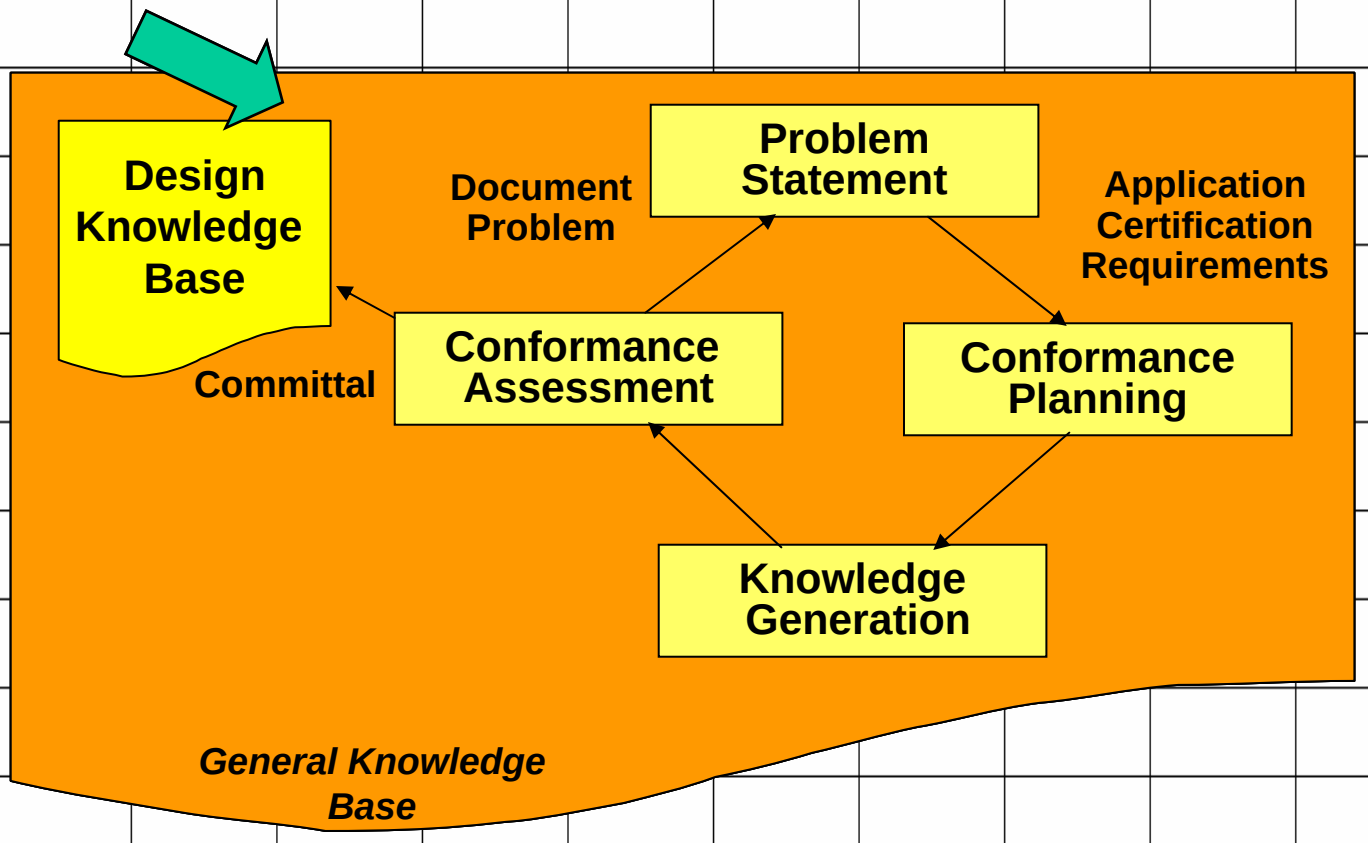
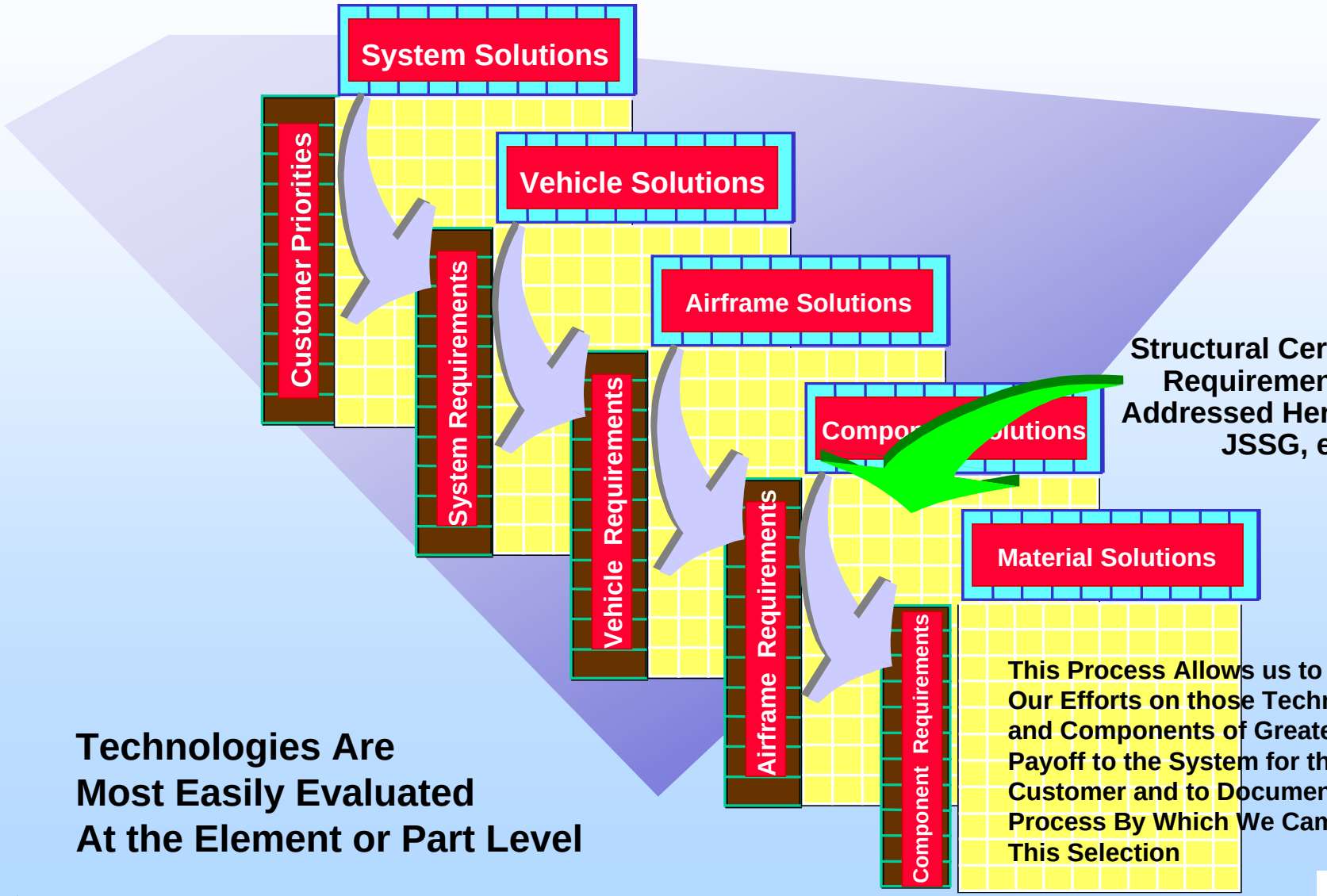
Cost / Schedule											
Intellectual Property											



AIM-C Links Requirements from the System to the Technology / Material



Structural Certification Requirements Are Addressed Here: FARs, JSSG, etc

This Process Allows us to Focus Our Efforts on those Technologies and Components of Greatest Payoff to the System for the Customer and to Document the Process By Which We Came to This Selection

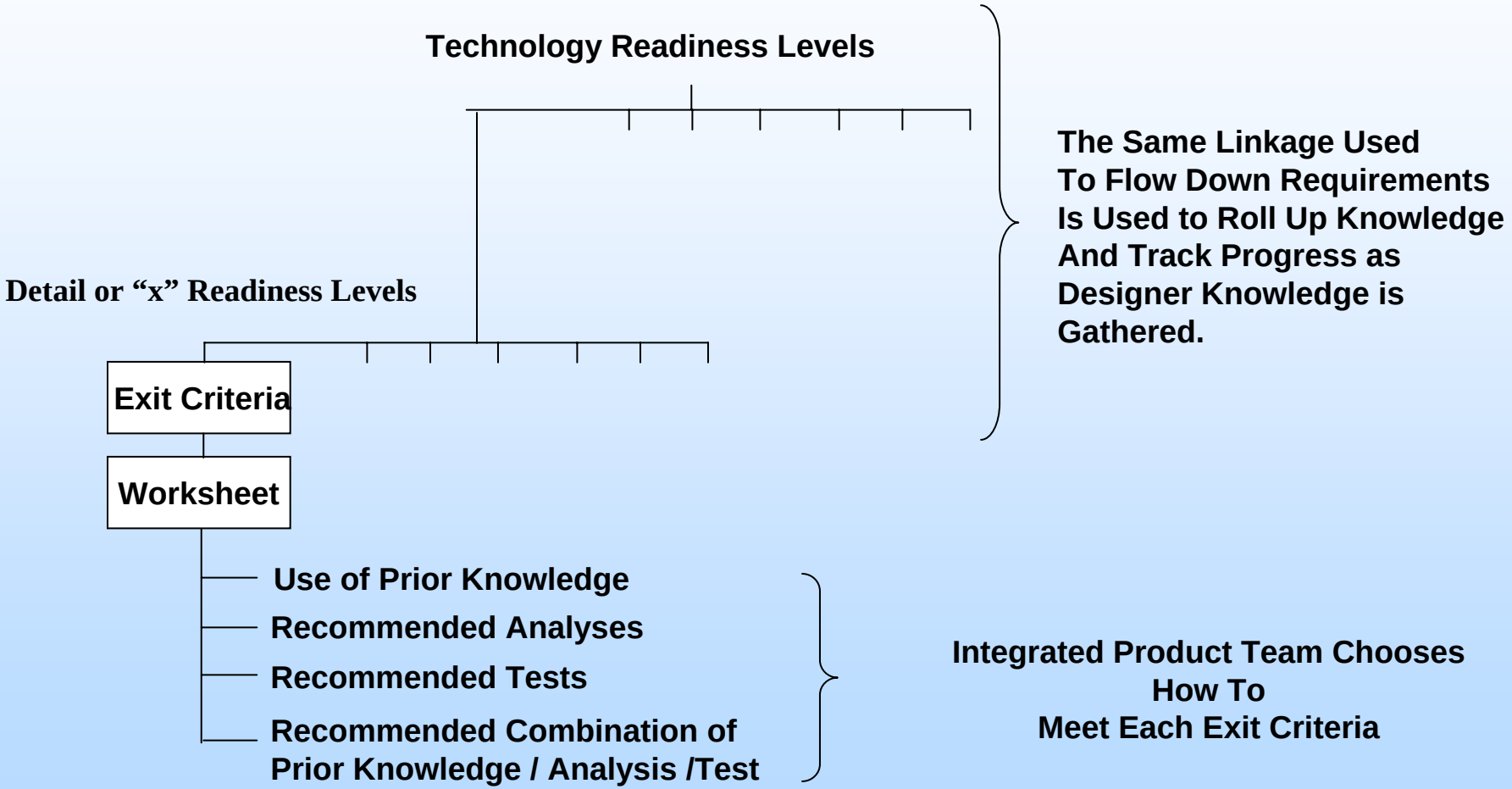
Technologies Are Most Easily Evaluated At the Element or Part Level

Conformance Planning

2.1		TEST TYPE/PROPERTIES - FIBER	0	1	2	3	4	5	6	7	8	9	10	
		Fiber Form and Type (Uni and Cloth, ie 5hs or plain or 8hs etc.)		x	x									
2.1.1	➢	Tensile Strength	x	x	x	x	x							Test-Analysis
2.1.2	➢	Tensile Modulus E11 (longitudinal)	x	x	x	x	x							Test-Analysis
2.1.3	➢	Tensile Strain to Failure	x	x	x	x	x							Test-Analysis
2.1.19		Compressive Strength				o								Analysis
2.1.20		Cost	x	x	x	x	x							Specified Value
2.1.21		T(g)		x										Test
2.1.22		wet T(g)		x										Test
2.1.23		Health and Safety		x										MSDS
2.1.10		CTE - Radial			o									Analysis
2.1.11		Filament Diameter	x		x		x							Test
2.1.12		Filament Count	x		x		x							Test
2.1.13		Transverse Bulk Modulus			o									Analysis
2.1.14		Youngs Modulus, E22 Transverse			o									Test
2.1.15		Shear Modulus, G12			o									Analysis
2.1.16		Shear Modulus, G23			o									Analysis
2.1.17		Poissons Ratio, 12			o									Analysis
2.1.18		Poissons Ratio, 23			o									Analysis
2.1.4	➢	Yield (MUL)	x	x	x	x	x							Analysis
2.1.5	➢	Density	x	x	x	x	x							Test
2.1.6		Heat Capacity (Cp)			x									Test
2.1.7		Thermal Conductivity Longitudinal			x-o									Analysis
2.1.8		Thermal Conductivity Transverse			x-o									Analysis

AIM-C Helps the IPT Plan Its Maturation Process

Knowledge Gathering

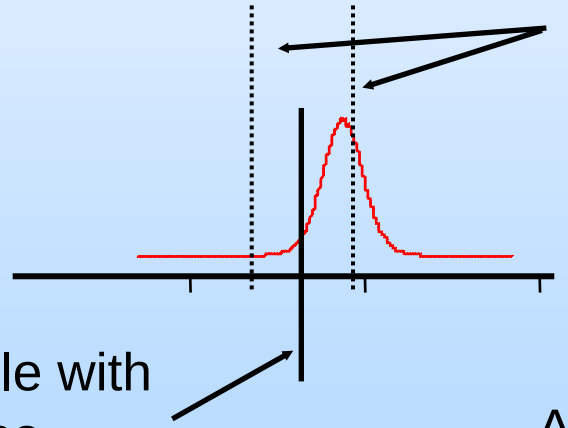


Conformance Assessment Data from Knowledge, Analysis, and Test – Design Values with Uncertainty

•Existing Data with replicates => can estimate design values (quantities and confidence bands)

•RDCS allows simulation of physical data with sources of randomness including batch effects (aleatory or random uncertainty) => can simulate design values.

•Combined data: design values with uncertainty bands



Bayesian uncertainty band on analysis based properties

Property estimate = quantile with confidence band. This is the "aleatory"/measured content

Aleatory and Bayesian are kept separate

AIM Allows the IPT to Track Progress

TRL	0	1	2	3	4	5	6	7	8	9	10
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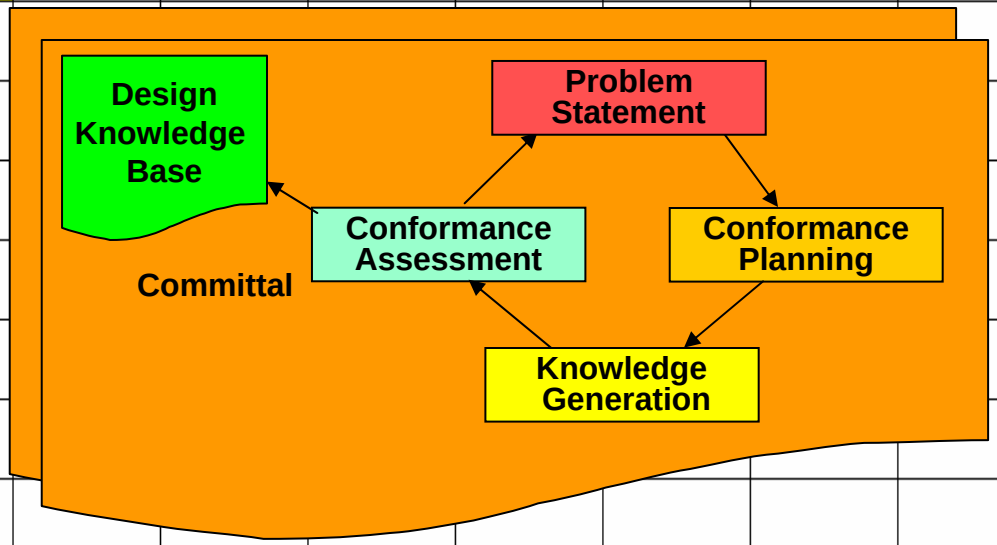
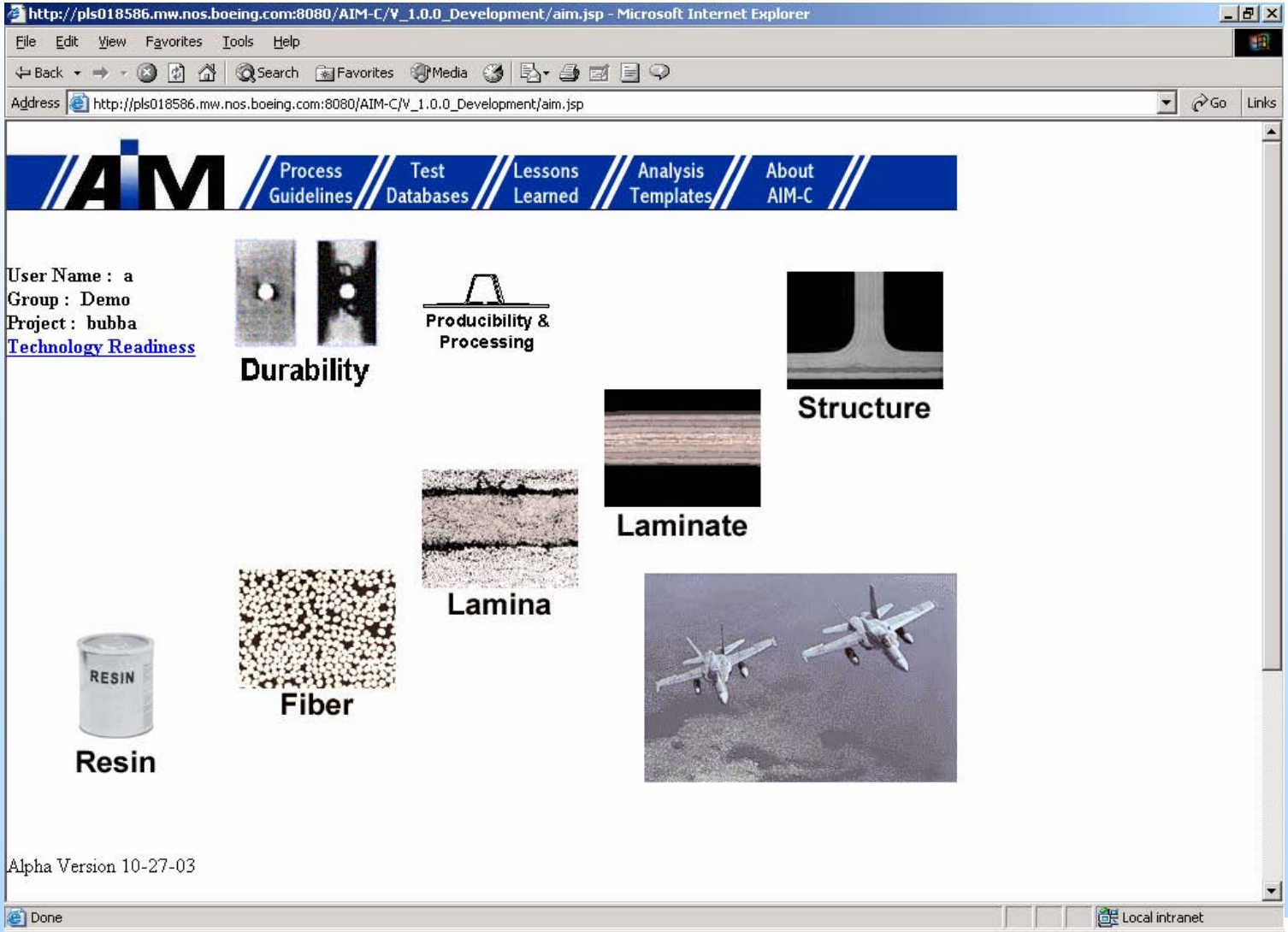
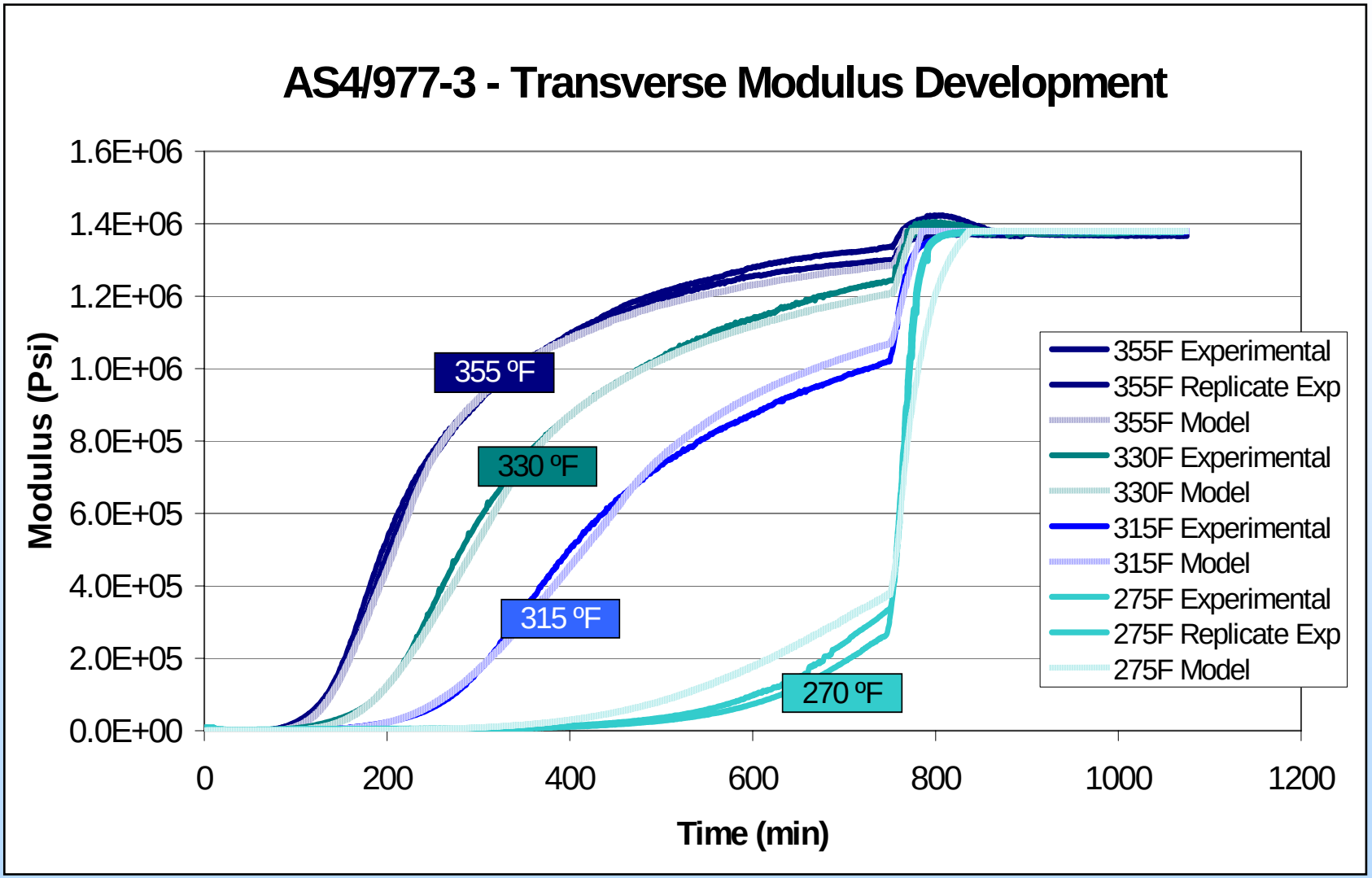


AIM Has Assembled a Web-Based System to Help the IPT Apply the Process

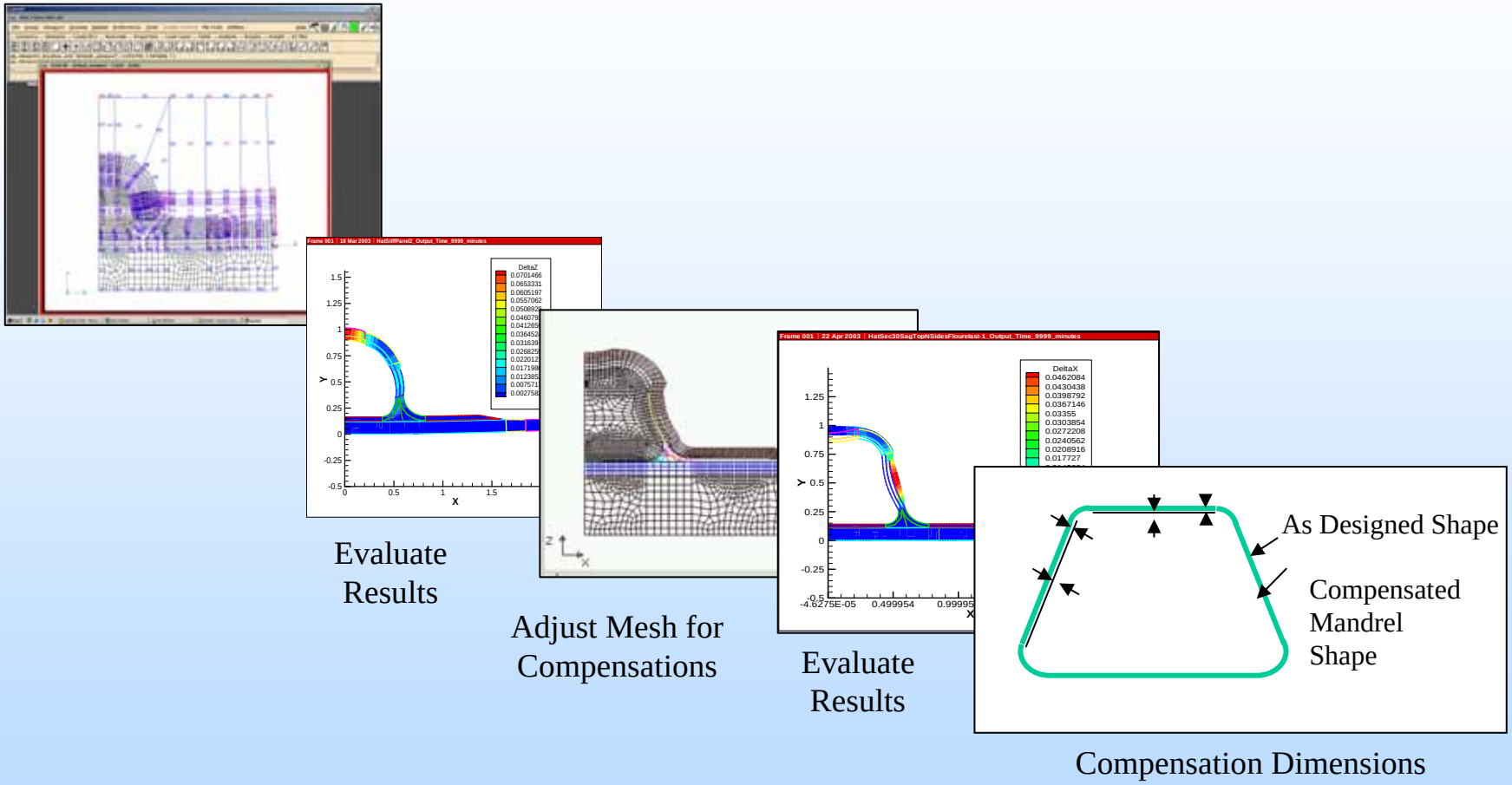


How Do Materials Engineers Use AIM-C?



AIM-C Helps Monitor Conformance to Requirements

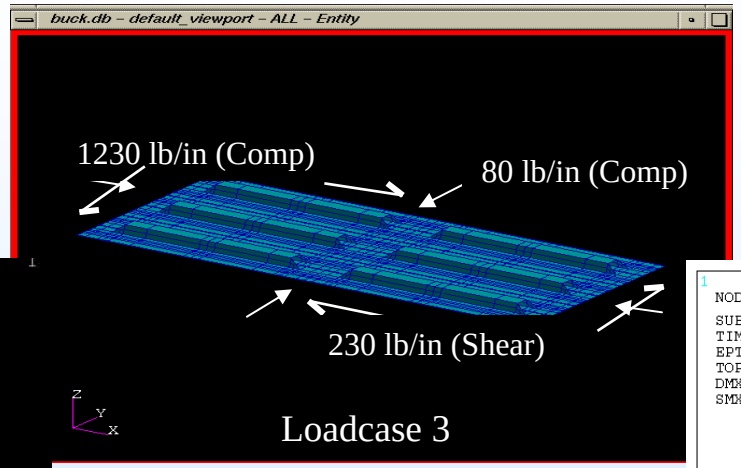
How Does Manufacturing Use AIM-C?



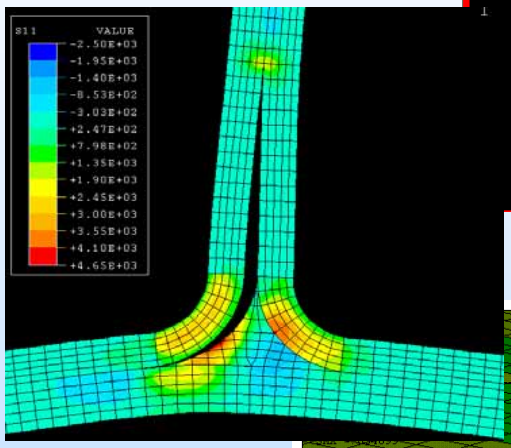
AIM-C Helps Identify Analysis Tools to Guide Fabrication

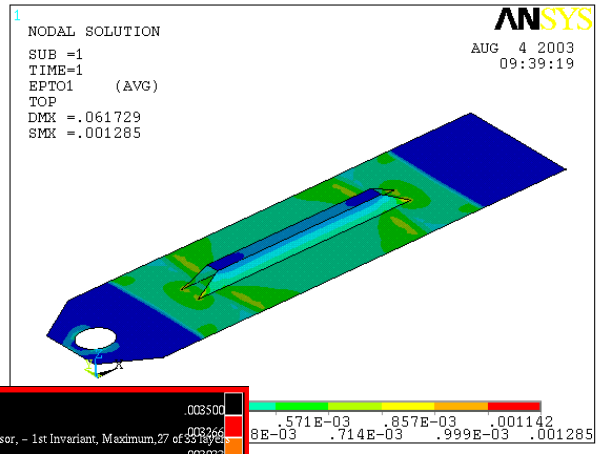
How Do Structures Engineers Use AIM-C?

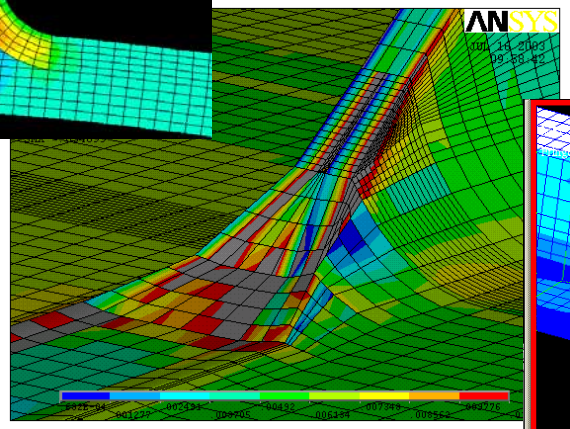
Fed Back to FEM
For Verify Satisfaction
Of Requirements

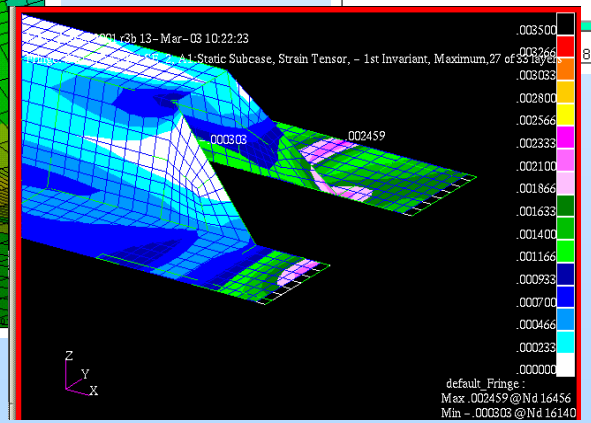


From Full FEM
to Segments









Details to
Effects of
Defects

Segments to
Elements

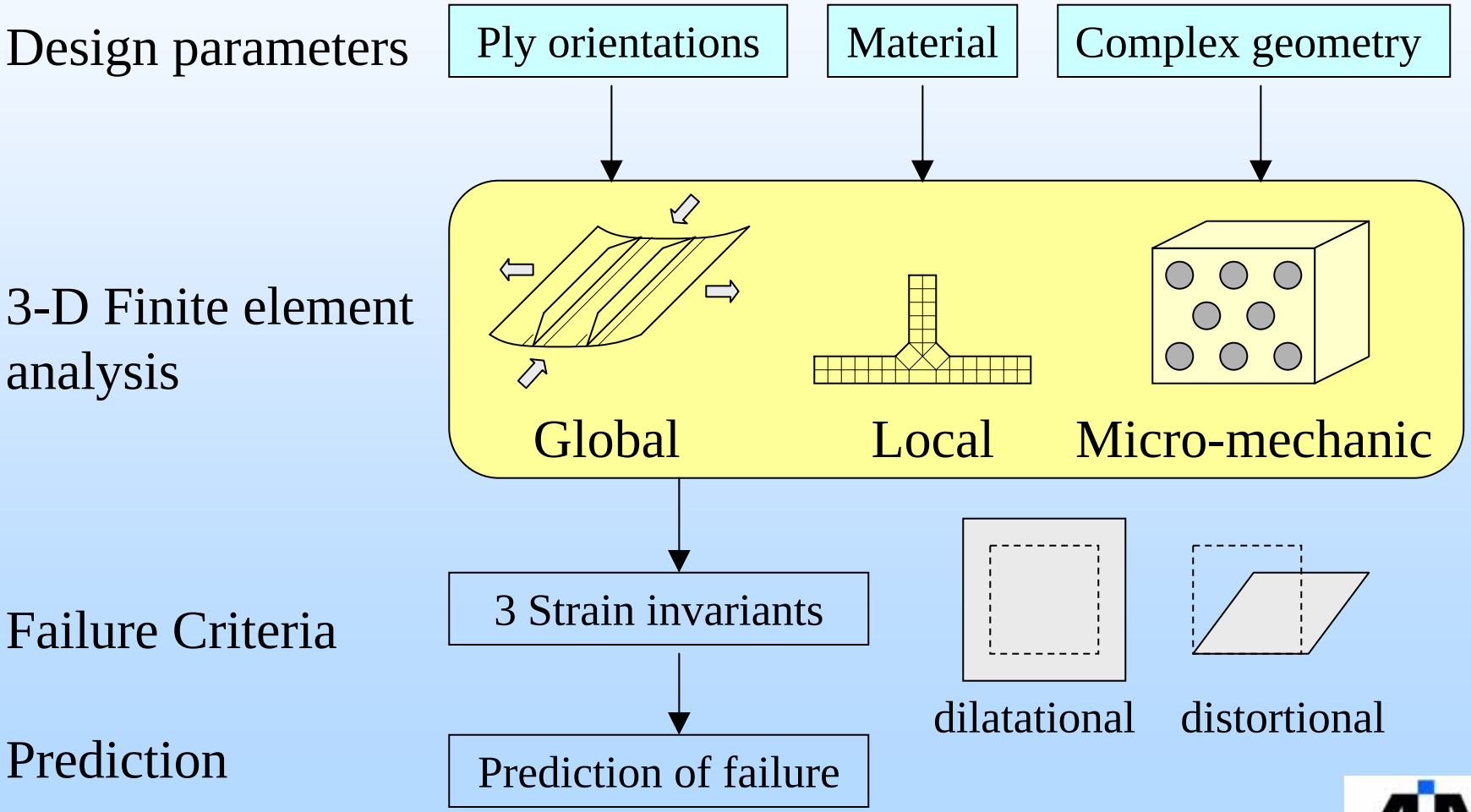
Elements to
Details

AIM-C Helps Plan the Maturation Process

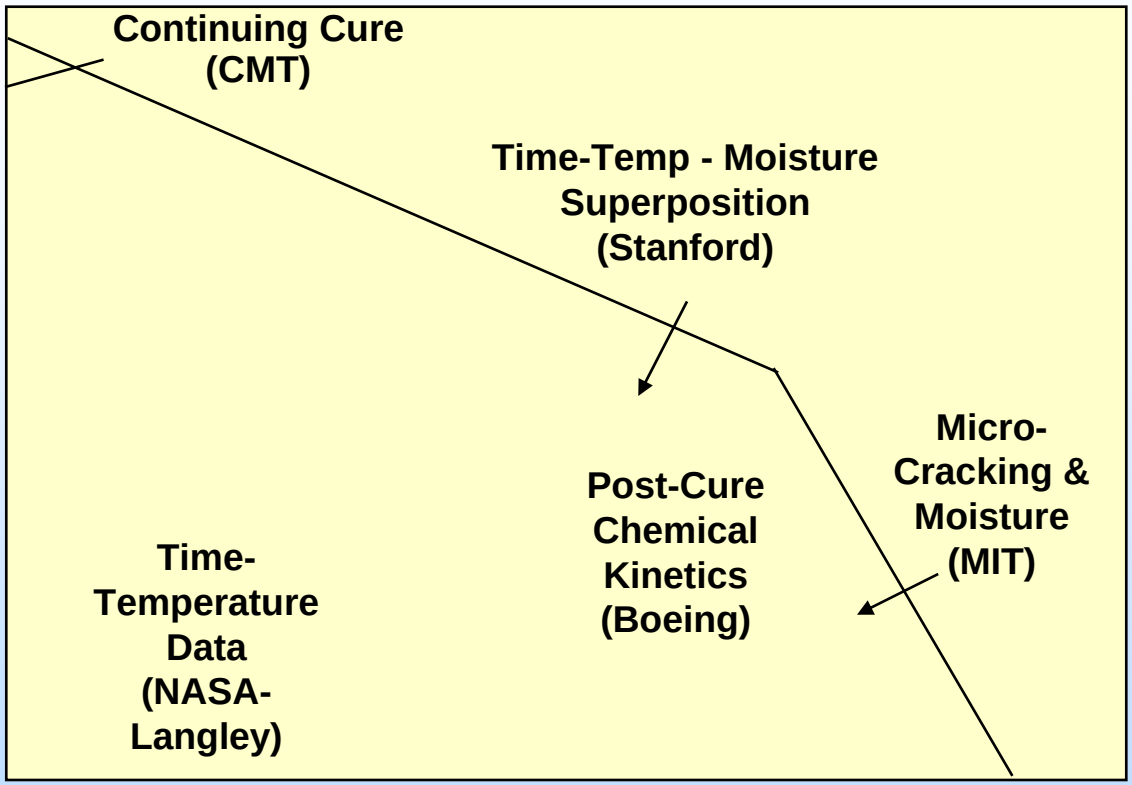
Approval for Public Release; Distribution Unlimited

How Does AIM-C Assess Strength?

Detailed 3D FEA of complex structures
combined with simple strain-based failure criterion
(SIFT)



How Does AIM-C Assess Durability?

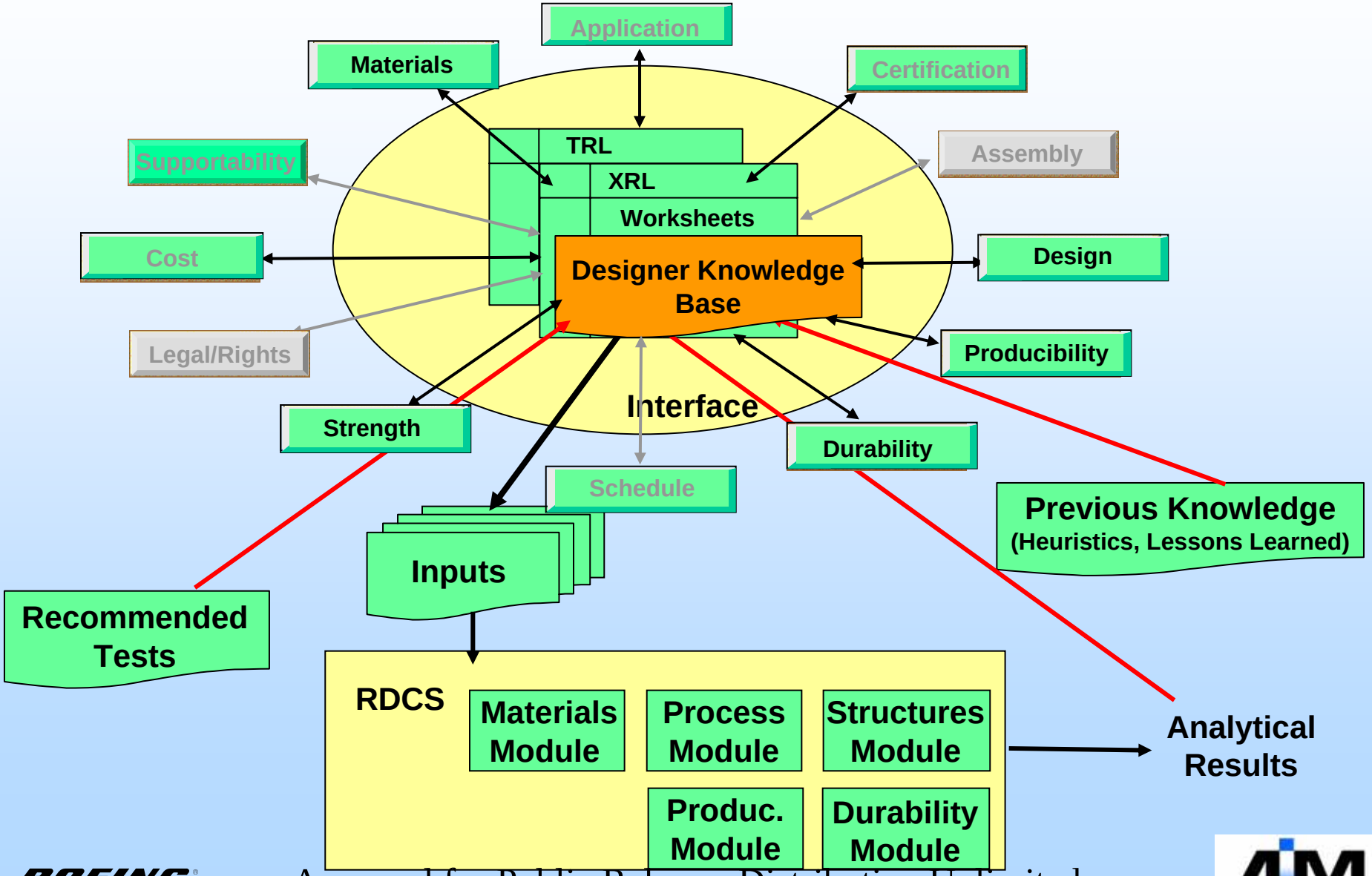


Strain Capability

Log Time at Load

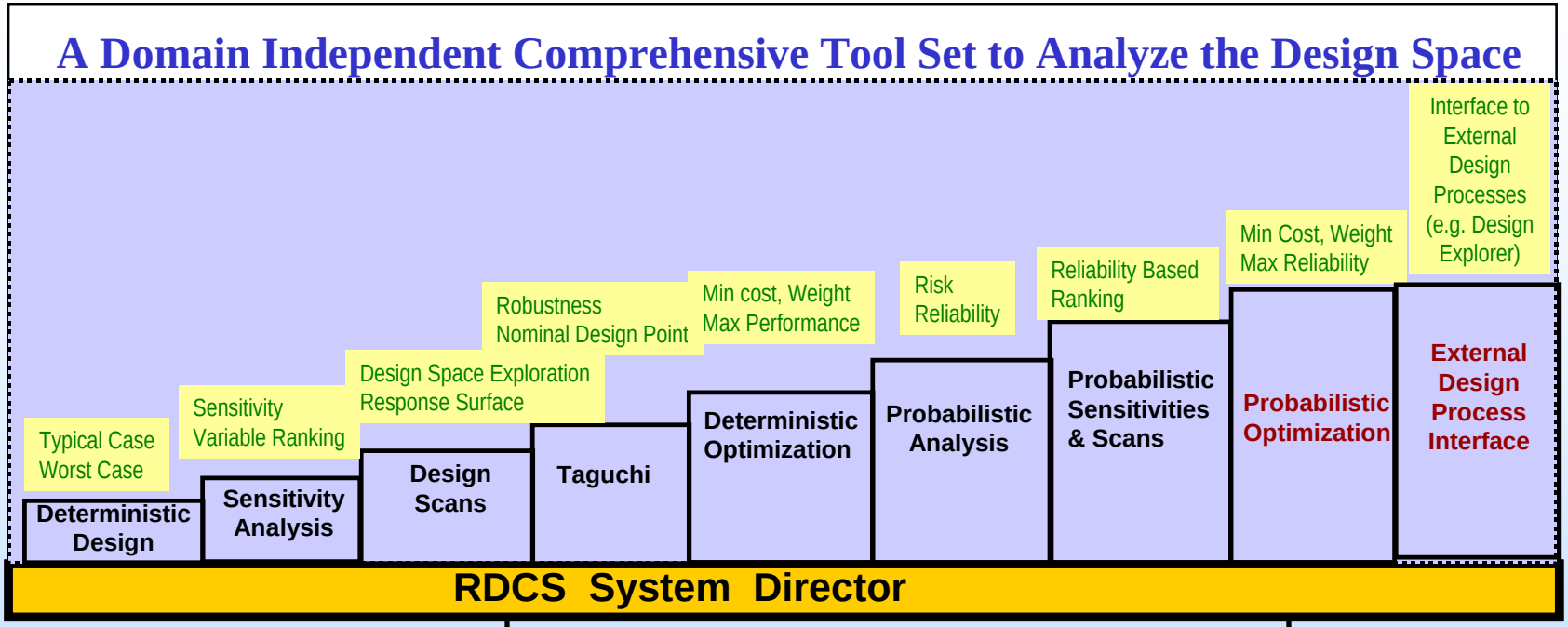
This Module Predicts the Effects of Four Competing Failure Modes – Time, Temperature, Environment and Chemical Degradation

The AIM-C System Uses These Tools to Produce a DKB That Meets Certification Requirements



Robust Design Computational System

Wide Variety of Error Propagation and Uncertainty Analysis Tools



AIM-C Three Step Validation Approach

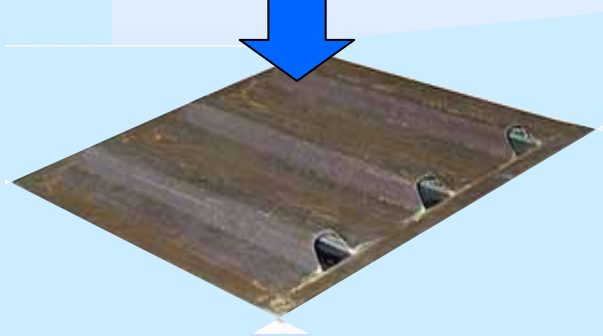
Step 1

Individual Module and System Validation

Existing Data

Step 2

Demonstrations and System Validation of Improvements



System Demonstration and Tests of Compelling Demo Validate Projected Means and Scatter

Step 3

Blind Validation

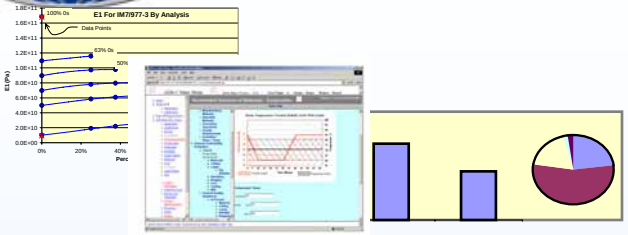
Known Design Requirements

NGC IPT Uses AIM-C

Validates Technical Results, Time Reductions, Cost Reductions

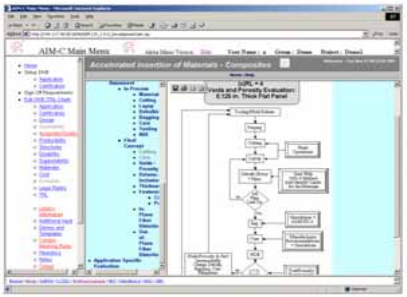
DARPA

NAVAIR

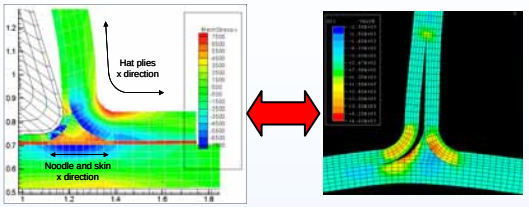


DKB Re-creation

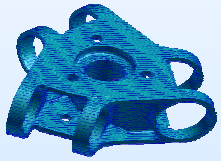
Encoded Heuristics

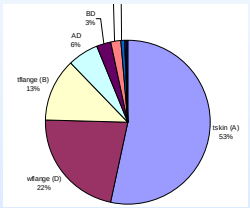


Producibility



Processing data passed to Structural Analyses

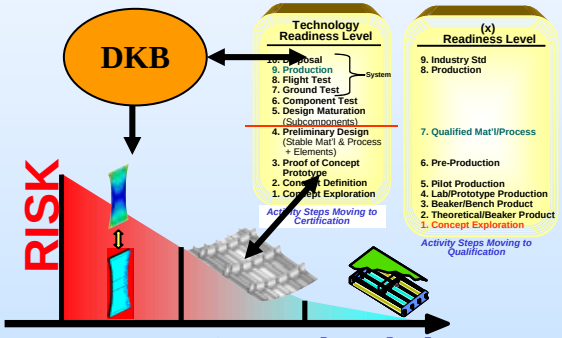




Design, ANOVA, Design Explorer, & Probabilistic Optimization RDCS Links

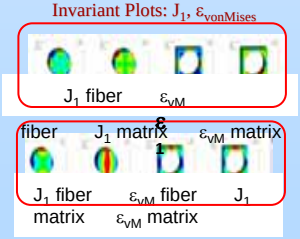
AIM-C Significant Accomplishments

TRL xRL

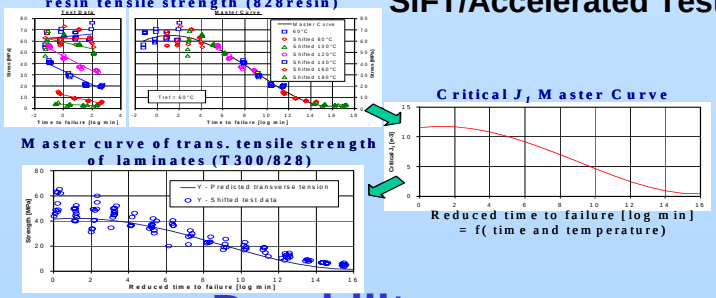


AIM-C Methodology Links Readiness Levels

Physics Based 3D SIFT & Fracture Failure Theories

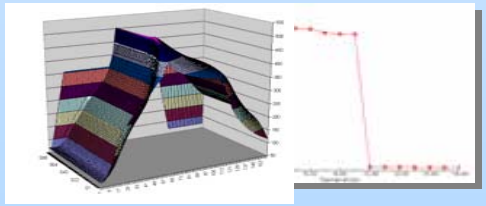


Structures



Durability

SIFT/Accelerated Testing



Materials & Processing

BOEING

Approval for Public Release; Distribution Unlimited

AIM Accelerated Insertion of Materials

Where is AIM Being Used?

Materials Selection for X-45

Composite Flap for F/A-18 E/F

Transparencies for 7E7